

A S S E S S M E N T

in a competition for an academic position "**Associate Professor**" in a Professional field **4.1. Physical sciences** (General theory of relativity and relativistic astrophysics), announced in DV, No. 30 / 15.04.2022 for the needs of the Faculty of Physics at Sofia University "St. Kl. Ohridski", with candidate: **Kalin Viliyanov Staykov, PhD, head assistant**

Member of the scientific jury: Petko Lubenov Nedialkov, PhD, Associate Professor

1. General characteristics of the candidate's research and applied research activity

The candidate's research activity is focused in the field of modified theories of gravity and the general theory of relativity, covering phenomena from relativistic astrophysics. In general, the subject of his research is both the modeling of compact objects (black holes and neutron stars) and the study of their parameters and properties in modified theories of gravity, and the study of quasi-normal modes (gravitational waves) of these objects and the study of the space-time around them.

In particular, the accelerated expansion of the universe observed only about a quarter of a century ago and the fact that GR is not renormalizable are just two of the reasons for this theory to be modified. A possible non-trivial approach is to couple the invariants to a scalar field and to add to the action second-order curvature invariants, the latter, with one exception, leading to pathologies in theory such as instabilities, ghost fields and others. This exception is the so-called Gauss-Bone gravity, where the scalar field (massively self-acting in black holes or an ensemble in neutron stars) is coupled to the so-called Gauss-Bonnet invariant, and a significant part of the works proposed for habilitation is worked on in this approximation.

Numerical calculations of the frequency of oscillations and the damping time in the axial quasinormal modes of black holes are investigated by means of the time evolution of the perturbation equation as a function of the mass of the scalar field and the self-action constant. Various characteristics of black holes and the space-time around them, such as the area of the horizon, the entropy and the radius of the photon sphere, have also been systematically studied.

Other considerations have been conducted within the framework of generalizations of general relativity such as scalar-tensor theories, etc. and $f(R)$ gravity, which is equivalent to a specific class of

scalar-tensor theories. Here, for neutron stars, the focus is on deriving relations independent of the equation of state between different dimensionless combinations of parameters or the frequencies of their quasi-normal modes. Numerical calculations are made using two different approaches: performing evolution over time of the perturbation equations and solving the time-independent equation as a boundary value problem.

The minimum national requirements for holding the academic position of "associate professor" in a professional field 4.1. Physical sciences are satisfied: according to indicator A the candidate has acquired PhD, according to indicator B (publications equivalent to a monographic work) the candidate has 100, with the required 100 points; according to indicator D (publications outside the monograph) there are 210, with the required 200 points. Accordingly, the sum of the points on indicator E (citations) is 162, with the required 50 points.

2. Assessment of the pedagogical preparation and activity of the candidate

According to a certificate from the Human Resources Department, available in the package of documents to the competition, the only candidate holds the academic position of head assistant at the Faculty of Physics for more than 5 years, from 15.06.2017 until now. His teaching activity exceeds the required. Separately, his teaching experience, expressed both in work experience and in total study load, far exceeds the required full study load for two years.

Although the candidate does not have a special pedagogical qualification, I am sure that his teaching is extremely high, as evidenced by the results of recent student surveys. The majority, and often 100% of students, believe that head assistant Kalin Staykov presents the study material in a systematic and accessible way, shows tact and correctness in communicating with students, he is interested in the extent to which the student has mastered the taught material, teaching methods used to understand and assimilate the studied material and provides sufficient materials to support the practical training in the specified discipline.

3. Main scientific and applied contributions

The main scientific contributions of the candidate are the field of modified theories of gravitation and the general theory of relativity, covering phenomena from relativistic astrophysics. Here I will give an example with only the two of the most significant contributions in my opinion, which meet the national requirements for holding the academic position of "Associate Professor" in the

professional field 4.1. Physical sciences. According to criteria B-item 4 and D-item 7 (scientific publications in publications that are referenced and indexed in world-recognized databases with scientific information), the candidate has submitted 9 publications with his significant contribution. I will illustrate the contributions with the two released impressive publications from 2022, in which Kalin Staykov is the first author. In publication [5] of Appendix 1, the significant contribution of the candidate is expressed in the numerical study of the quasi-normal modes of black holes in Gauss-Bone gravity with a massive self-acting scalar field. Numerical solutions for black holes, both spontaneous and non-spontaneous, have been obtained, and by time evolution of the axial perturbation equation, **the profiles of the emitted gravitational waves have been obtained**, from which the frequencies and attenuation times have subsequently been derived. In the publication [6] of Annex 1, the significant contribution of the candidate is expressed in obtaining solutions for scalarized non-topological neutron stars in Gauss-Bone gravity with multiple scalar fields. The obtained solutions are for a coupling function that allows spontaneous scalarization, in which case the source of the scalarization is the curvature of space-time. The majority of the contributions in the presented publications are the personal work of the candidate. This is evident not only from his place among the co-authors, but also from the assurance of Prof. Stoycho Yazadjiev, which explicitly states that “the main scientific contributions of head assistant Dr. Kalin Viliyanov Staykov ... correspond to the scientific results published in the scientific papers submitted for participation in the competition for associate professor, in which he has a significant contribution.” Most contributions can be described as "proving with new means significant new aspects of existing scientific fields". The candidate's scientific works have been published in the most prestigious journals in theoretical physics and astrophysics and have been cited many times in the world's leading journals in the same field.

4. Significance of contributions to science and practice

The candidate has significant scientific results in the modeling of black holes and neutron stars and the study of gravitational waves from these compact objects in modified theories of gravity. Here I want to emphasize strongly that the phenomenological effects associated with them are subject to experimental verification.

Regarding the quantitative indicators of the additional requirements to the candidates for the academic position of "Associate Professor" at the Faculty of Physics of Sofia University "St. Kliment Ohridski " in direction 4.1. Physical sciences, they are also fully implemented. The candidate has 5 years of teaching experience, equivalent to full, with the required 2 years, classroom employment at

Sofia University and scientific supervision of three (> one) successfully defended graduates. In group indicators B and D the candidate has 12 with the required 7 publications from group I. With the required significant contribution in at least 4 of the publications from group I, the candidate has a significant contribution in 9 publications, 3 of which have been published in the last 3 years 1 such publication. If 1 guide or 1 participation is required, the applicant has submitted evidence of participation in 5 international or national projects. Its h-index is 10, with a nominal requirement of 5. The criterion for the sum of points on the quotations indicator (E), which is 162, at 100 points according to the additional requirements, is also fulfilled.

5. Critical remarks and recommendations

I have neither general or formal remarks, nor recommendations to the scientific works of the candidate.

CONCLUSION

The presented scientific papers contain enough and impressive scientific and applied contributions. On the basis of the acquaintance with the presented scientific works, their significance, the scientific, scientific-applied and applied contributions contained in them,

I find it justified **to propose** Kalin Vilianov Staykov **to take the academic position of "Associate Professor"** in the professional field 4.1. Physical Sciences (General Theory of Relativity and Relativistic Astrophysics) at the Faculty of Physics at Sofia University "St. Kliment Ohridski",

Date: July 20, 2022

JURY MEMBER: